

Status, habitat and preliminary observations on calling of the Green and Golden Bell Frog *Litoria aurea* on Bowen Island, Jervis Bay National Park

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ABSTRACT

An extensive survey was conducted on Bowen Island, Jervis Bay National Park, to locate and describe the breeding sites of *Litoria aurea*. Five small potentially suitable wetlands were located from aerial photographs and systematic foot-based traverses of the island. Opportunistic monitoring of these sites was undertaken during the period early November 1995 to late January 1996. Low numbers of males were heard calling at three of the five sites, but no indication of successful breeding was recorded. All wetlands on the island were found to be naturally occurring and none contained fish. A preliminary description of the wetlands and observations on the seasonal extent of calling is presented. Because the island is effectively buffered from nearby mainland populations of *L. aurea*, the island population should be given a priority for conservation, and appropriate monitoring and management conducted to ensure its long-term survival.

INTRODUCTION

There is considerable evidence that the Green and Golden Bell Frog *Litoria aurea* has contracted significantly in its distribution in New South Wales, with remaining sites being confined to the coastal lowlands (White and Pyke 1996; Osborne *et al.* 1996). Many of the remaining extant populations occur in highly-disturbed sites in coastal urban areas such as Sydney and Wollongong (Daly 1995a; Goldingay 1996; White and Pyke 1996) and few remaining breeding populations have been found in comparatively natural habitats (Clancy 1996; Pyke and White 1996; White and Pyke 1996). By contrast, in East Gippsland in Victoria the frogs are still common and occupy a range of natural and modified habitats (Gillespie 1996).

In the Nowra region the frogs still occur at a number of locations, including Shoalhaven Heads (White and Pyke 1996), Coomonderry Swamp (Daly 1995a, 1996), Beecroft Peninsula (Coyne *et al.* 1979) and Jervis Bay National Park (Daly 1995b). However, many of the remaining breeding sites are somewhat artificial; for example at Coomonderry Swamp the frogs are believed to breed in farm dams adjacent to the swamp (Daly 1995a), and at Jervis Bay the species is currently known to occur only in a shallow artificial swamp created by earth works at the former Atomic Energy Commission (AEC) site near Murray's Beach (Daly 1995b), although former sites with the species include Ryan's Swamp and Lake McKenzie (A. Georges, University of Canberra, pers. comm.).

In February 1995 a single adult *L. aurea* was found by G. Daly on the eastern side of Bowen Island (Daly 1995b). This was the first record of

the species from the island. Several natural freshwater swamps provide potential breeding sites on the island (Ingwersen 1976; Fortescue 1991). The presence of an island population of *L. aurea* is of considerable biogeographical and conservation significance. In this paper we present an assessment of *L. aurea* on the island, describe its breeding habitat, and provide a preliminary analysis of our observations on chorusing behaviour.

Description of the Island

Bowen Island lies north of Governor Head near the northeastern tip of Bherwerre Peninsula, approximately 30 km south-east of Nowra, New South Wales. The island is 51 ha in extent with a maximum height of 41 m, and is composed of Permian sandstone capped by Quaternary sand (Albani *et al.* 1973). The sandstone dips westward, resulting in the formation of cliffs up to 30 m high on the eastern edge of the island and gently sloping rock platforms and beaches along the western shoreline. Wind blown sand of varying depths occurs over much of the island, forming deep vegetated dunes on the western side. The island has a mean annual rainfall of 1 220 mm (Fortescue 1991).

European development first occurred on the island in 1928 when the first of a series of leases was granted. Fortescue (1991) suggested that the island had been burnt almost annually by fishermen and that it had been occasionally used for grazing livestock. In 1942 the island was acquired for defence purposes, and a series of buildings and other defence installations were constructed. Following this, the island was leased again, with occupation continuing until

the lease expired in 1985. Regular burning of the island apparently resulted in removal of much of the original cover of woodland and scrub. In the 1950s large parts of the island consisted of grassland, but the *Banksia* woodland and tall heath has subsequently regenerated extensively, partly as a result of plantings, and now shows signs of senescence in many areas (Fortescue 1991, 1995 and pers. comm.).

The island vegetation now comprises three main types. The exposed western edge of the island is dominated by a dense ground-cover of Matrush *Lomandra longifolia*. On the deeper dune soils there are extensive areas of *Banksia* woodland with small areas of *Casuarina* in the wetter low-lying areas. The eastern side of the island is now dominated by tall heath (Ingwersen 1976).

METHODS

Frog Surveys

A preliminary visit to Bowen Island was made in July 1995 to search for potential breeding sites which had been mapped by Ingwersen (1976) or identified from examination of a colour aerial photograph. The entire island was also searched by undertaking a series of linear traverses (this was aided by the presence of a grid of slightly cleared trails that had been established previously for the laying of rat baits; P. Meek, pers. comm.). The locations of wetlands and potential wetlands (low-lying areas subject to seasonal inundation) were marked on an aerial photograph and later transcribed to a topographic map (Fig. 1). A description of the structure of the vegetation at each potential breeding site was made and a list of the common terrestrial and aquatic plant species prepared.

From 10 October 1995 to 6 February 1996, one of us (NM) lived on the island and regularly checked each of the potential breeding sites by listening for calls and visually inspecting the wetlands for resting frogs. The number of individuals calling and consistency of calling throughout the day was examined at two small wetlands on the island (Site 2 and 5; Fig. 1) where *L. aurea* was observed to be calling. An automatic call recorder (Faunatech, Glen Iris, Victoria) was used to record the frog chorus on five days (14–18 November 1995) at Site 2. Five minutes of sound were recorded automatically using a timer set at half hourly intervals throughout the day from 8.45 am to midnight. In addition, on eight days a 45 minute continuous tape recording of the chorus was made commencing at dusk. Air temperature measured 5 cm above the water, water temperature measured two cm below the water surface and humidity at the edge of the water were recorded at the start and finish of most recording sessions. Wind strength and cloud cover were noted at the time of the recording.

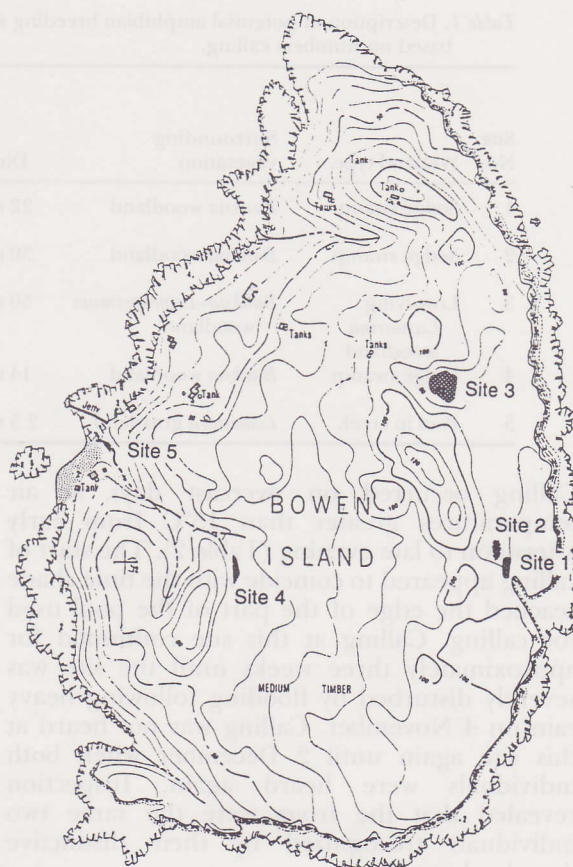


Fig. 1. Location of sites surveyed for *Litoria aurea* on Bowen Island, Jarvis Bay. Note heights shown are in feet. Base map provided by Australian Nature Conservation Agency, Jarvis Bay.

RESULTS

Five wetlands potentially suitable for *L. aurea* were found (Table 1; Fig. 1). All of these were dry in February 1995 (G. Daly pers. comm.), however, by July the sedge swamps (Sites 1, 2 and 4; see Fig. 1) contained water. Site 3, a low-lying *Casuarina* woodland subject to infrequent flooding, remained dry until 5 October when it filled to a depth of about 40 cm following torrential rain. A small, deeply incised creek on the western side of the island adjacent to the ranger station was identified as a fifth possible site (Site 5) because it contained a large pool with overhanging grass and other dense ground cover. This pool, however, was only a few metres from a beach, and was frequently affected by salt water during higher tides. In addition, the site was occasionally subject to flooding from storm waters moving down the creek.

Sites 1 to 5 were examined at approximately weekly intervals commencing on October 4. *Litoria aurea* were first heard calling on 26 October 1996 when two individuals were heard calling at the creek pool near the ranger station (Site 5) (Table 2). Both males called regularly from the water amongst floating debris beneath overhanging vegetation at the edge of the pool.

Table 1. Description of potential amphibian breeding sites on Bowen Island. Estimate of number of *L. aurea* present based on numbers calling.

Site No.	Wetland type	Surrounding vegetation	Dimensions	Mean depth	Substrate	Estimate of number of <i>L. aurea</i> present
1	Sedge swamp	<i>Banksia</i> woodland	22 m × 10 m	30 cm	organic debris and sand	0
2	Sedge swamp	<i>Banksia</i> woodland	30 m × 11 m	30 cm	organic debris and sand	8
3	Low-lying <i>Casuarina</i> woodland	<i>Banksia</i> – <i>Leptospermum</i> woodland	50 m × 47 m	40 cm	organic debris roots and sand	5
4	Sedge swamp	<i>Banksia</i> woodland	14 m × 5 m	20 cm	organic debris and sand	0
5	Pool in creek	<i>Lomandra</i> grassland	2.5 m × 1.5 m	20 cm	sand	2

Calling occurred on overcast days at air temperatures greater than 15°C from early afternoon to late evening (Table 2). The start of calling appeared to coincide with the time shade reached the edge of the part of the pool used for calling. Calling at this site continued for approximately three weeks until the site was severely disturbed by flooding following heavy rain on 4 November. Calling was not heard at this site again until 2 December when both individuals were heard again. Inspection revealed that the frogs were the same two individuals (recognized by their distinctive dorsal coloration).

Table 2. Selected climatic variables measured during periods of calling by *L. aurea* at Site 5.

Date	Time (hrs)	No. calling	Air temp.*	% Humidity*	% cloud cover
26/10	1500	2	20.0	55	100
27/10	1530	1	18.1	77	100
28/10	1630	2	15.9	83	100
29/10	1715	2	19.1	85	80
30/10	1520	2	17.1	66	100

*Recorded 12 m from pool

At 0920 am on 5 November, following a torrential downpour of rain overnight (55 mm fell at nearby Jarvis Bay village), a chorus estimated to comprise at least eight individuals was heard calling in full sunshine at Site 2. The water temperature at a depth of 2 cm was 21°C and the air temperature at water level was 22°C. Calling persisted in regular bouts until about 1100 hrs and by 1230 had stopped. Several individuals were observed sitting on sedges just above water level, but the individuals calling were not observed. On the same day, no frogs were heard calling at the other four sites. The following day, two *L. aurea* were also heard calling at Site 3, which was now flooded.

At Site 2, where regular monitoring was conducted, calling continued sporadically for about two weeks and then stopped. Call transcription from the automatic call recorders indicated that

by 10 days after the chorus was first heard, calling no longer occurred during the day, and was restricted to the late afternoon and evening between about 1730 and 2030 hours. The chorus was not continuous, and on 8, 9 and 13 November when 45 minutes of calling at dusk was recorded, the total number of minutes during which calling was detected amounted to totals of 30, 9, and 12 minutes consecutively (Table 3).

No amplexing pairs or spawn were observed at any of the sites on any occasion. No *L. aurea* tadpoles were observed during spotlighting, and none were captured during dipnetting.

Description of Potential Breeding Habitat

Brief descriptions of the sites at which *L. aurea* were heard calling on the island are given below.

Site 2 is near the location where Daly (1995b) found the first specimen on the island. It consisted of a shallow open ephemeral wetland located on sandstone about 50 m west of the cliffs providing the western edge to the island. The wetland measured approximately 10 × 37 m with an average depth of about 30 cm. The swamp bottom sediment consisted of peat to a depth of about 30 cm over much deeper sand, although in places the sandstone was exposed. The main aquatic vegetation consisted of a low (<60 cm), dense cover of sedges and rushes surrounding small areas of open water amounting to about 16 m². The main species associated with the wetland were sedges and aquatic plants, including *Baumea juncea*, *B. rubiginosa*, *B. articulata*, *Juncus continuus*, *Schoenus brevifolius*, *Villarsia exaltata* and *Triglochin procerum*. A tall open scrub dominated by *Allocasuarina distyla*, *Baeckea imbricata*, *Banksia ericifolia* and *Leptospermum squarrosum* surrounded the wetland. The undergrowth in much of this area consisted of a dense tangle of shrubs, sedges and grasses. The scrub surrounding the wetland gradually graded into a drier tall shrubland characterized by the following shrubs: *Leptospermum laevigatum*, *Banksia serrata*, *Acacia longifolia*, *Xanthorrhoea resinifera*,

Table 3. Results of 45 minutes of continuous sound recording made at Site 2 at dusk.

Date	Start time	Days since chorus first commenced	Total number of 1 min. intervals in which calls detected	Water temp. (°C)	Air temp. (°C)	Humidity (%)
8/4/95	1943	3	30	20.1	20.8	42
9/11/95	1921	4	9	21.4	21.2	85
13/11/95	1950	8	13	18.3	17.9	75
18/12/95	2015	43	1	20.1	—	83
19/12/95	2110	44	0	17.6	16.5	76
26/12/95	2045	51	0	18.5	—	85
27/12/95	2220	52	0	18.5	16.3	76
28/12/95	2215	53	0	17.8	17.6	81

Olearia tomentosa, *Actinotus helianthi*, *Ricinocarpus pinifolius*, *Elaeocarpus reticulatus*, *Bossiaea ensata*; and the following ground cover species: *Pteridium esculentum*, *Opercularia diphylla*, *Tricoryne simplex*, *Stipa mollis*, *Lepidosperma concavum* and *Themeda australis*. No open grassland was found anywhere near Site 2.

Site 3 consisted of a *Casuarina glauca* woodland which occupied a low-lying, sandy basin surrounded by scrub and woodland-dominated dunes. The site is generally dry but on rare occasions becomes flooded during periods of very high rainfall (M. Fortescue, pers. comm.). During the period of our survey an area of about 14 m × 5 m became flooded to a depth of about 40 cm, but by the end of December had dried.

Prior to flooding the site was open, consisting mainly of leaf litter and the roots, stems and trunks of *Casuarina*. The ground cover also included patches of *Lomandra longifolia*, *Baumea juncea*, *Isolepis nodosa* and *Paspalidium* sp. The surrounding scrub and woodland included the following tall shrubs and low trees: *Monotoca elliptica*, *Banksia serrata*, *B. ericifolia*, *B. integrifolia*, *Leptospermum laevigatum*, and *Baeckea imbricata*, with a moderately dense ground cover of shrubs (*Dillwynia glaberrima*, *Elaeocarpus reticulatus*, *Acacia longifolia*, *Opercularia diphylla*) and grasses (*L. longifolia*, *Gahnia siebariana*, *Schoenus brevifolius*, *Deyeuxia quadrisetata*, *Entolasia stricta*, *Eragrostis brownii* and *Hemathria uncinata*).

Site 5 consisted of a small pool (approx. 1.5 × 3 m) near the mouth of an ephemeral creek draining the southwestern side of the island (Fig. 1). The pool was situated at the bottom of a steep-sided gully that cut into a vegetated dune adjacent to a small beach. The pool was affected by salt water from the sea during particularly high tides, although the high flow rate in the creek presumably flushed out the salt water (pers. obs.). The pool substrate consisted of sand and debris carried down by the creek. The banks of the pool were partially covered with grass (*Pennisetum clandestinum*) which overhung the water, and provided calling sites and shelter for the frogs. The surrounding

area was densely vegetated by grass and tall tussocks of *Lomandra*. The site is surrounded by scattered penguin nesting burrows, and the creek provided an access route for large numbers of adult penguins each night (pers. obs.).

DISCUSSION

The finding of a breeding population of *L. aurea* on Bowen Island is of considerable interest, especially with respect to the population declines which have seriously affected mainland populations in New South Wales (White and Pyke 1996; Osborne *et al.* 1996). Due to its isolation from factors influencing mainland populations of *L. aurea*, the island provides a potential refuge for the species. Currently no Mosquito Fish *Gambusia holbrooki* occur on the island. *Gambusia* are effective predators of small tadpoles including *L. aurea* (Morgan and Buttemer 1996) and are strongly implicated in the decline of the species (Daly 1995a; Pyke and White 1996). Because they are active foraging predators, fish can eliminate tadpoles from ponds, and may be one reason why most of the known remaining populations of *L. aurea* are breeding in freshwater wetlands that do not contain *Gambusia* (Daly 1995a; Morgan and Buttemer 1996; Pyke and White 1996).

The origin of the *L. aurea* population on the island is not known. It may be a relict population that has always occurred on the island, or it may have more recently colonized the island. If it is a natural population it would have persisted on the island for some 6 000 years since Holocene sea levels were low enough to have connected the island with the mainland (Blackwell 1980). The survival of *L. aurea* on such a small island during this lengthy period appears problematic, especially given that only one other species of frog, *Crimia signifera* occurs on the island, and that the population size would always have been small. At least 17 species of frogs occur on the nearby mainland (Daly 1995b), with 10 species known from the AEC site at Murray's Beach (pers. obs.) and it would be surprising if populations of some of these were not successful in colonizing and persisting on Bowen Island.



Plate 5a. A female *L. aurea* found by G. Daly near site 1 on the eastern side of Bowen Island. Photo: G. Daly.



Plate 5b. A *L. aurea* photographed in its basking site near Murrays Beach car park, Jervis Bay National Park. Note how the green and brown blotching helps camouflage the frog when it is sitting amongst sedges. Photo: W. Osborne.

If the *L. aurea* population on Bowen Island is relictual then it is of considerable conservation significance, particularly if, as a result of lengthy isolation and apparently small population size, it has become genetically divergent (e.g., Colgan 1996). If the population is not of relictual origin then it must have arrived on the island by crossing the sea barrier. Given the general low tolerance of frogs to sea water (Tyler 1976; Duellman and Trueb 1986; Ferraro and Burgin 1993) it is highly unlikely that they would have survived the 300 m swim from the mainland. Instead it is more reasonable to expect that the population was accidentally established during the period that construction materials were being regularly transported to the island. Whilst such translocations are rarely successful, deliberate establishment of new populations of *L. aurea* have been made in New Zealand (Bell 1982), New Caledonia (Greer 1994) and the New Hebrides (Tyler 1979).

The observations on calling by *L. aurea* reported here have some implications for the design of surveys for this species. Many frogs found in southeastern Australia call intensely

for prolonged periods on suitable nights throughout lengthy breeding seasons (e.g., Dankers 1977; Osborne 1985) and thus are readily detected by aural censuses (Heyer *et al.* 1994). However, it is possible that *L. aurea* does not call as regularly during its breeding season. Instead, it has been suggested that reproductive activity is highest in summer immediately after heavy downpours of rain (Daly 1995a, and pers. comm.). The most detailed data on chorusing in this species is given by Dankers (1977) from a field study conducted near Sydney. Although Dankers found that the frogs call regularly during the period mid-September to mid-December, the calling intensity of the frogs was often comparatively weak in terms of the proportion of available time during which calling was heard. Whilst many species call almost continuously and are easy to detect with an automatic sound recorder, the infrequency of the calling bouts by *L. aurea* makes it a difficult species to detect using this approach, particularly if the recording intervals are of short duration. As noted by White and Pyke (1996) (also G. Gillespie, pers. comm.) considerably more adult frogs can be present at a site than is suggested by visual encounter survey or calling.

Clearly, more research is required into the chorus dynamics of *L. aurea*, before surveys can be reliably based on aural censuses. Fortunately, the large size and comparative conspicuousness of the species increases their ease of detection during visual encounter surveys. Further research on appropriate census techniques for this species is required, before standardized surveys and monitoring can be effectively conducted. The development of appropriate methodology is an integral component of the recovery research and management recommended for this species (see Goldingay 1996).

The population of *L. aurea* on Bowen Island is of regional significance and should be given some priority in conservation plans. All wetlands on the island are of natural origin and free of fish, an important feature considering the concern about populations of the species at sites where Mosquito Fish *Gambusia holbrooki* are present (Daly 1995a; Morgan and Buttemer 1996; Pyke and White 1996). Because the island is effectively buffered from nearby mainland populations of *L. aurea* the island population should be given a priority for conservation, and appropriate monitoring and management conducted to ensure the long-term survival of this unusual population.

ACKNOWLEDGEMENTS

The Australian Nature Conservation Agency provided permits and funds to support this study. We particularly thank Martin Fortescue

(ANCA) for his encouragement, enthusiasm and considerable logistical support during the field work. Without Martin's assistance, often in his own time, the field work would not have been possible. We also thank the Jervis Bay police for assistance when one of our party was bitten by a funnel web spider. Garry Daly kindly provided details of his discovery of *L. aurea* on the island and he and Thea van de Mortel provided information on the species in the Nowra region. Maxine Davis expertly identified plants that we collected, and Scott Thomson and Alex Osborne assisted with field work. We are grateful to Garry Daly, Graeme Gillespie, Ross Goldingay and Thea van de Mortel for providing helpful comments on the manuscript.

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